

Affective Domain and Student Learning in the Geosciences

David A. McConnell¹ and Katrien J. van Der Hoeven Kraft²

ABSTRACT

Decades of science education research have provided us with a variety of tools to deal with the cognitive processes behind our students' learning. However, we have placed much less attention on student *affect*, the feelings, attitudes, emotions, and values that can encourage or discourage the adoption of effective learning behaviors. This has occurred even though the affective domain has been demonstrated to have a significant influence on student learning. An increased awareness of the role of the affective domain in the sciences has the potential to improve student learning, boost recruitment of majors, and reduce student attrition. We propose that the geoscience education research community would benefit from giving greater consideration to the role of the affective domain as a key component of the learning process. © 2011 National Association of Geoscience Teachers. [DOI: 10.5408/1.3604828]

INTRODUCTION

Walt Whitman (Whitman, 1900) begins his poem, *When I heard the Learn'd Astronomer*, imagining himself in the audience of a lecture:

When I heard the learn'd astronomer;

When the proofs, the figures, were ranged in columns before me;

When I was shown the charts and the diagrams, to add, divide, and measure them;

When I, sitting, heard the astronomer, where he lectured with much applause in the lecture-room,

It was a particularly good lecture (how often do we receive applause?), but Whitman cannot sit still and soon finds himself outside:

How soon, unaccountable, I became tired and sick;

Till rising and gliding out, I wander'd off by myself,

In the mystical moist night-air, and from time to time,

Look'd up in perfect silence at the stars.

Like Whitman, many of our students have an appreciation for the phenomena of nature but often have less interest for the technical details behind the phenomena. Decades of research on science education have provided us with a variety of tools to deal with our students' conceptual understanding of the geosciences, the cognitive processes behind their learning. But there has been less focus on student *affect*: the feelings, attitudes, emotions, and values that shape learning and behavior. Like Whitman, our

students may feel disconnected from the nature we strive so hard to define for them and they often struggle to see the relevance of the content to their lives. Greater attention paid to the affective domain provides an opportunity to strike a balance between the content of science and the motivation necessary to support the learning of the content. An increased awareness for the role of the affective domain may provide opportunities to both improve student learning and boost recruitment of majors.

AFFECTIVE DOMAIN AND STUDENT LEARNING

A survey of geoscience teaching faculty at a major research institution (Markley *et al.*, 2009) recently reported that 69% of respondents believed that student motivation had a major impact on learning (in contrast with just 8% who believed that the teaching methods they used were significant). Student motivation is part of the affective domain, which also addresses student emotion and regulation of learning. Ultimately, the affective domain addresses the question of *why* our students learn. However, we pay little attention in the geosciences education community to determine why students choose to engage or disengage with the content. We do spend a lot of time discussing *how* people learn topics best, focusing on the cognitive domain. The use of effective cognitive strategies (thinking, reasoning, etc.) is positively related to student performance, but student adoption of these strategies is either limited or promoted by affect and self-regulated learning processes (Pintrich, 2003). Wolters and Pintrich (1998) linked many cognitive and affective factors together when they stated that "*interest and value can help a student choose to become involved in a task, somewhat like the 'starter' for a car, but once involved, the self-regulation process of strategy use and adaptive efficacy beliefs are more important for 'steering' and controlling actual performance*" (p. 44).

The affective domain has been demonstrated to have a significant influence on student learning. For example, Perry *et al.* (2007) showed a profound link between students' feeling of "control" and learning. Robbins *et al.* (2004), Covington (2007), Pekrun (2007), Zusho *et al.* (2003), and McConnell *et al.* (2010) demonstrated that some aspects of student *motivation* have more significant influences on college student performance (as measured by class

Received 20 November 2010; revised 18 April 2011; accepted 24 May 2011; published online 1 August 2011.

¹Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina 27695, USA

²Department of Physical Science, Mesa Community College, Red Mountain Campus, Mesa, Arizona 85207, USA

scores) than does student *ability* (measured by standardized test results such as ACT/SAT scores).

The geosciences have been slow to investigate the link between the affective domain and teaching and learning, despite emerging research that highlights the importance of the affective domain in promoting student learning. But do not feel too bad about it, we are not alone in this regard. A search for the term *cognitive* in all NSF award descriptions issued over the last decade (January 2000 to December 2010) yielded more than 2500 results. A similar search for the term “affective” produced about a tenth the number of hits. Looking for the term *cognitive domain* in the Google Scholar database for science and engineering articles published over the same time period produced five times as many results as for the term *affective domain*.

Affect in Practice

Consider the following three scenarios in the context of the affective domain. Which students are more engaged with the content? In which case(s) is learning most likely to be mediated by the students’ affect?

Scenario A:

Cathy: “Did you do the homework assignment?”

Megan: “Yes, but I hate it, its just busy work so he can see if we have opened the book.”

Cathy: “I know, I just make up lists of definitions and I never know which I should memorize for the test. Why can’t he just give a study guide with the important terms so I don’t waste my time?”

Megan: “Too right, these science classes are all the same, just a bunch of facts to memorize. Sooo boring!”

Scenario B:

Ron: “Did you do the homework assignment?”

Dexter: “Yes, I hate the fact that we have to summarize the chapters, but at least it forces me to get organized for the exams.”

Ron: “I guess, but I’m never sure if I’m making notes on the right things.”

Dexter: “I agree with you there. I see what she is trying to do but I’m not sure how much most people actually get out of it.”

Scenario C:

Karl: “Which of the homework assignments did you do?”

Jen: “Volcanoes, probably the most interesting topic for the semester so far. I wouldn’t mind visiting some of *those* places.”

Karl: “Yeah, me too! I hadn’t realized how many active volcanoes there are in the US.”

Jen: “At first I wasn’t sure what to take notes on, but the learning objectives he gave us helped me figure it out so I didn’t spend a lot of time on the small stuff.”

What is the difference between the three student conversations? The first two have a disinterest for the assignment, but in the second scenario, they understand its role and *why* they need to engage. In the third case, students are interested in both the material and the task and seek to successfully complete the assignment.

These different student scenarios provide an opportunity to examine the components of the affective domain more closely. The perception of a task will be strengthened if the student believes that it has relevance to their life and/or some utility beyond the class itself. A student who places more value and interest in the task typically shows greater learning, persistence, and effort (Wigfield and Eccles, 2002; Hidi and Renninger, 2006). At the same time that the student is making these judgments she will also be making a decision about how easy it will be to complete the task (ease of learning judgment), including how confident that she can complete the task successfully (self-efficacy). Students with high self-efficacy expect to be successful, will try harder, persist longer on tasks, and generally perform better on course assignments than do students who have lower expectations (Pintrich and DeGroot, 1990; Pintrich, 2003; Bykerk-Kauffman *et al.*, 2009; McConnell *et al.*, 2010). A student who knows what is needed in order to complete a task will begin with low task (test) anxiety, whereas a student who perceives the task as difficult or is unclear on the expectations may begin with heightened anxiety that can interfere with the learning process. Effective self-regulation strategies would also include making a specific plan to complete the work, including an assessment of the amount of effort involved, and a willingness to seek help as a strategy. Those that take control of their learning beliefs are more likely to attribute success or failure to adaptable factors such as effort (Zimmerman, 1998; Alderman, 2008). This control of learning can be facilitated by providing students with choices in their learning. Finally, students who feel an intrinsic desire to learn more about the content are more likely to be engaged in learning, and those who have a more extrinsic orientation will focus on succeeding academically (Ryan and Deci, 2000), which on its own can result in a grade-focus, but in combination with an intrinsic motivation can result in a high performing and interested student.

In scenario A, Cathy and Megan were focused on the extrinsic value of the task, because they had no interest or value for the assignment. In addition, because their work was not supported (i.e., no work samples or grading rubric), it may have helped to increase their anxiety and decreased their overall feelings of self-efficacy, and as a result created a negative affective experience for these students, which results in a decrease in interest and motivation for the topic.

In scenario B, Dexter and Ron were able to find some value in the task, so there may have been an increase in intrinsic value, but because it was not supported, it continued to increase anxiety. Because there was some connection to how this may help Dexter learn, it is possible that the activity helped support his feelings of self-efficacy, but clearly that is not the case for all students as Ron illustrates

with his concerns. In addition, the professor has control of the assignment, providing the students with little choice in the format or topic. Students like Dexter, who are highly self-regulated, will be successful with almost any learning task, however Ron may represent those students who may need more support to be successful. With both students, however, the interest for the content has declined due to the lack of positive affective factors.

In the third scenario, Karl and Jen have some choice over their task, with results in a greater task value and intrinsic motivation. In addition, access to the learning objectives helped Jen to feel supported and increased her feelings of self-efficacy, which may in turn better prepare her for a successful future assessment experience. These students may also have an extrinsic orientation, due to the assignment being part of their grade, but it is well supported by their interest and intrinsic values.

The affective domain is not completely absent from geoscience education research. While not explicitly defined by many researchers, it is visible in several recent articles from the *Journal of Geoscience Education*. For example, a search from the past year has revealed:

- [Arthurs and Templeton \(2009\)](#) sought to develop activities with a personal connection to students in an environmental geology course that also incorporated affective characteristics such as fun, curiosity, and creativity.
- [Dadd \(2009\)](#) introduced “real-life” exercises in an environmental geology course that have the potential to enhance student value in the lessons.
- [Eaton \(2009\)](#) discussed the use of collaborative exams as one strategy that was aimed at enhancing student interest (and perhaps reducing test anxiety) in an introductory geoscience course.
- [Eppes \(2009\)](#) described how students designed semester-length geomorphology projects, thus providing them with greater control of their learning environment and promoting intrinsic learning goals.
- [Lutz and Srogi \(2010\)](#) argued for the incorporation of discussions of the different ways in which people value the natural world in geoscience classes.
- [Trend \(2009\)](#) suggested that the introduction of argumentation skills can enhance student interest and motivation in classwork.

Measuring the Affective Domain

Efforts at cognitive research may contain indirect references to affect when they include comments about how students enjoyed a particular task. However, the relevant components of the affective domain often remain unmeasured, and their link to student learning is therefore untested. Exceptions to this may use existing instruments such as the Attitudes toward Science Survey (ATSS; [Bickmore et al., 2009](#)), or self-created instruments such as Likert scale responses to a statement about confidence in ability (self-efficacy; [Sunderlin, 2009](#)), or the interest and importance of the geosciences ([Palmer et al., 2009](#)), or the enjoyment or usefulness of a particular task ([Kennelly, 2009](#)).

We already use standard instruments such as the Geoscience Concept Inventory (GCI; [Libarkin and Anderson, 2005](#)) to measure student understanding of key geoscience concepts. It is not a great leap from here to begin to utilize valid and reliable measuring tools to define student scores

on aspects of the affective domain using the ATSS or other instruments such as:

- Motivated Strategies for Learning Questionnaire (MSLQ; [Pintrich et al., 1991](#)).
- Intrinsic Motivation Inventory (IMI; [Ryan and Deci, 2000](#)).
- Study Process Questionnaire (RSPQ2F; [Biggs et al., 2001](#)).
- Academic Motivation Scale (AMS; [Vallerand et al., 1992](#)).
- Learning and Study Skills Inventory (LASSI; [Cano, 2006](#)).

Some of these instruments can be divided into a variety of separate subscales that can be administered independently. Regardless of which scale we use, or which aspect of the affective domain we seek, if we are to unravel the role of affect in promoting geoscience learning, we must begin to make direct efforts to design studies that determine which aspects of affect best enhance learning in different contexts.

We are members of a multi-institution, NSF-funded collaborative research project (GARNET = Geoscience Affective Research NETwork) that is examining the connection between students use of the affective domain, instructor teaching strategies, learning environments, and class characteristics in college-level introductory physical geology. Our research group began with 7 institutions (2 community colleges, 1 private 4-year liberal arts college, a comprehensive public university, and 3 public research universities) and is currently expanding to include about a dozen more schools. GARNET's goal is to establish a baseline of data on the affective domain that will inform future research in the geosciences and in other STEM disciplines. Our initial research utilized the MSLQ ([Pintrich et al., 1991](#)) and has confirmed that the affective domain has a major influence on student learning in the geosciences, and that student-centered teaching methods have a more positive influence on student affect than traditional, teacher-centered instruction ([Bykerk-Kauffman et al., 2009](#); [Gilbert et al., 2010](#); [McConnell et al., 2010](#)). We interpret this latter result to indicate that the class is the appropriate level of analysis for institutional results as we see contrasts among instructors when many other variables (e.g., class size) are constant. There is a pressing need to look more closely at the nature of the teaching and learning processes in classes to characterize the factors that contribute to consistent improvements in student affect.

Students often come to our classes with a genuine interest in the topic ([Arthurs and Templeton, 2009](#); [Gilbert et al., 2010](#)), but programs often struggle to add majors. As far as our students are concerned, we appear to be unable to make a compelling case for sustaining, let alone increasing, the number of geoscience majors. Similar results have been identified from surveys of middle and high school students ([Kitts, 2009](#)) many of whom prove capable of doing science but do not *want* to do science. This despite predictions for increasing demand for geoscientists in the next decade ([Bureau of Labor Statistics, 2010](#)) and the fact that starting salaries are typically higher in the geosciences than several other sciences ([NACE, 2009](#)). Why are students seemingly disinterested in majoring in the geosciences? What can we do to motivate them to find greater value in the science of Earth? These questions cry out for

research on aspects of the affective domain if we are to grow the number of geoscientists to meet future demand.

Notions of attending to affect are not limited to conversations in academia. In his popular best-seller, *Drive*, author Daniel Pink (2009) described how some companies had made dramatic gains in productivity by giving their workers opportunities to set their own (intrinsic) goals and to take some measure of control of their tasks and their work environment. Pink revealed how affective factors he categorized as mastery, purpose, and autonomy were stronger motivators than higher salaries in promoting employee satisfaction and retention.

SUMMARY

We must consider both the cognitive and affective domains when conducting interventions to impact student learning and when designing programs that seek to recruit majors. We call for the geoscience community to begin to take explicit steps to measure student affect and determine ways to improve factors such as intrinsic goal orientation, self-efficacy, task value, and control of learning beliefs, factors that correlate with student learning. We can anticipate a range of questions that would be useful to answer as this research moves forward. For example, if we recruit most of our majors from introductory classes, we should make an effort to learn more about students' affective constructs in introductory courses, and how they relate to performance. Specifically, it would be useful to discover just which intervention strategies have a positive influence on student affect.

One benefit of the relative paucity of existing research on the affective domain in college science classes is that the geosciences have an opportunity to take leadership in this vital topic. We believe that the geosciences are well positioned to be able to address the role of the affective domain in teaching and learning. Geoscientists are natural story tellers (Bickmore *et al.*, 2009), and field experiences provide our students with the opportunity to engage in social experiences that help to generate a feeling of community and connection (Stokes and Boyle, 2009). Think back to what first attracted you to the geosciences. From our own experiences, we were not that different from Walt Whitman, many of us were first charmed and drawn in by the landscape around us and only later came to appreciate the figures, . . . *ranged in columns and charts and diagrams*. Perhaps our students also need to make that personal connection to the subject. Investigations of the components of the affective domain will inform us about which strategies help foster that connection and have the added benefit of promoting deep conceptual learning.

Acknowledgments

We wish to thank all of our GARNET collaborators, most of whom provided careful edits and suggestions for this article. GARNET participants include David Budd, Ann Bykerk-Kauffman, Lisa Gilbert, Megan Jones, Catharine Knight, Matthew Nyman, Dexter Perkins, Ronald Matheney, Jennifer Stempien, Tatiana Vislova, Merry Wilson, and Karl Wirth. We also thank collaborating faculty who permitted us to collect data in their classes at the California State University (Chico), Macalester College, North Carolina State University, University of Colorado

(Boulder), and University of North Dakota. Additional information about the GARNET project is available at the Science Education Resource Center website, <http://serc.carleton.edu/garnet/index.html>. This material is based upon work supported by the National Science Foundation under Grant Nos. 0914404 and 1022917.

REFERENCES

- Alderman, M.K., 2008, *Motivation for achievement: Possibilities for Teaching and Learning*, 3rd ed., Routledge: New York, NY, p. 282.
- Arthurs, L., and Templeton, A., 2009, Coupled collaborative in-class activities and individual follow-up homework promote interactive engagement and improve student learning outcomes in a college-level environmental geology course: *Journal of Geoscience Education*, v. 57, no. 5, p. 356–371.
- Bickmore, B.R., Thompson, K.R., Grandy, D.A., and Tomlin, T., 2009, On teaching the nature of science and the science-religion interface: *Journal of Geoscience Education*, v. 57, no. 3, p. 168–177.
- Biggs, J., Kember, D., and Leung, D.Y.P., 2001, The revised two-factor study process questionnaire: R-SPQ-2F. *British Journal of Educational Psychology*, v. 71, p. 133–149.
- Bureau of Labor Statistics, Geoscientists and hydrologists, retrieved from <http://www.bls.gov/oco/ocos312.htm>, July 8, 2010.
- Bykerk-Kauffman, A., Matheney, R.K., Nyman, M., Stempien, J.A., Budd, D.A., Gilbert, L.A., Jones, M.H., Knight, C., Kraft, K.J., Nell, R.M., Perkins, D., Teasdale, R., Vislova, T., and Wirth, K.R., 2009, The Effect of Student Motivation and Learning Strategies on Performance in Physical Geology Courses: Garnet Part 4, Student Performance. Geological Society of America Annual Meeting Abstracts with Program, Portland, OR, v. 71, no. 7, p. 604.
- Cano, F., 2006, An in-depth analysis of the learning and study strategies inventory (LASSI): *Educational and Psychological Measurement*, December, v. 66, p. 1023–1038.
- Covington, M.V., 2007, A motivational analysis of academic life in college: in, Perry, R., and Smart, J.C., eds., *The Scholarship of Teaching and Learning in Higher Education: An Evidence-Based Perspective*, Springer, Dordrecht, The Netherlands, p. 661–729.
- Dadd, K.A., 2009, Using problem-based learning to bring the workplace into the classroom: *Journal of Geoscience Education*, v. 57, no. 1, p. 1–10.
- Eaton, T.T., 2009, Engaging students and evaluating learning progress using collaborative exams in introductory courses: *Journal of Geoscience Education*, v. 57, no. 2, p. 113–120.
- Eppes, M.C., 2009, Introducing field-based geologic research using soil geomorphology: *Journal of Geoscience Education*, v. 57, no. 1, p. 11–22.
- Gilbert, L.A., Stempien, J.A., Matheney, R.K., McConnell, D., Perkins, D., van der Hoeven Kraft, K.J., Vislova, T., Jones, M.H., Nyman, M., and Budd, D.A., 2010, Retention in geosciences: what influences students to continue beyond an introductory undergraduate course?: *Geological Society of America, Abstract with Program*, v. 42, no. 5, p. 584.
- Hidi, S., and Renninger, K. A., 2006, The four phase model of interest development: *Educational Psychologist*, v. 41, no. 2, p. 111–127.
- Kennelly, P.J., 2009, An online social networking approach to reinforce learning of rocks and materials: *Journal of Geoscience Education*, v. 57, no. 1, p. 33–40.
- Kitts, K., 2009, The paradox of middle and high school students' attitudes towards science versus their attitudes about science as a career: *Journal of Geoscience Education*, v. 57, no. 2, p. 159–164.

- Libarkin, J.C., and Anderson, S.W., 2005, Assessment of learning in entry-level geoscience courses: results from the Geoscience Concept Inventory: *Journal of Geoscience Education*, v. 53, no. 4, p. 394–401.
- Lutz, T., and Srog, L., 2010, A values framework for students to develop thoughtful attitudes about citizenship and stewardship: *Journal of Geoscience Education*, v. 58, no. 1, p. 14–20.
- Markley, C.T., Miller, H., Kneeshaw, T., and Herbert, B.E., 2009, The relationship between instructors' conceptions of geoscience learning and classroom practice at a research university: *Journal of Geoscience Education*, v. 57, no. 4, p. 264–274.
- McConnell, D., Stempien, J.A., Perkins, D., van der Hoeven Kraft, K.J., Vislova, T., Wirth, K.R., Budd, D.A., Bykerk-Kauffman, A., Gilbert, L.A., and Matheney, R.K. (2010), The little engine that could – less prior knowledge but high self-efficacy is equivalent to greater prior knowledge and low self-efficacy: *Geological Society of America, Abstract with Program*, v. 42, no. 5, p. 191.
- NACE (National Association of Colleges and Employers), 2009, Salary survey, <http://www.nacweb.org>.
- Palmer, M.H., Elmore, R.D., Watson, M.J., Kloesel, K., and Palmer, K., 2009, Xoa: dau to Maunakui: Integrating indigenous knowledge into an undergraduate earth systems science course: *Journal of Geoscience Education*, v. 57, no. 2, p. 137–144.
- Pekrun, R., 2007, Emotions in students' scholastic development, in Perry, R., and Smart, J.C., eds., *The Scholarship of Teaching and Learning in Higher Education: An Evidence-Based Perspective*, Springer, Dordrecht, The Netherlands, p. 553–610.
- Perry, R.P., Hall, N., and Ruthig, J.C., 2007, Perceived (academic) control and scholastic attainment in higher education, in Perry, R., and Smart, J.C., eds., *The Scholarship of Teaching and Learning in Higher Education: An Evidence-Based Perspective*, Springer, Dordrecht, The Netherlands, p. 477–552.
- Pink, D.H., 2009, *Drive: The Surprising Truth about What Motivates Us*: New York, Riverhead Books, 242 p.
- Pintrich, P.R., 2003, A motivational science perspective on the role of student motivation in learning and teaching contexts: *Journal of Educational Psychology*, v. 95, p. 667–686.
- Pintrich, P.R., and DeGroot, E.V., 1990, Motivational and self-regulated learning components of classroom academic performance: *Journal of Educational Psychology*, v. 82, p. 33–40.
- Pintrich, P.R., Smith, D.A.F., Garcia, T., and McKeachie, W.J., 1991, A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ). Report 91-B-004, Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning, p. 87.
- Robbins, S.B., Lauver, K., Le, H., Davis, D., and Langley, R., 2004, Do psychosocial and study skill factors predict college outcomes? A meta-analysis: *Psychological Bulletin*, v. 130, p. 261–288.
- Ryan, R. M., and Deci, E. L., 2000, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being: *American Psychologist*, v. 55, no. 1 p. 68–78.
- Stokes, A., and Boyle, A.P., 2009, The undergraduate geoscience fieldwork experience; influencing factors and implications for learning: *GSA Special Paper*, Boulder, CO, v. 461, p. 291–311.
- Sunderlin, D., 2009, Integrative mapping of global-scale processes and patterns on “imaginary Earth” continental geometries: A teaching tool in an earth history course: *Journal of Geoscience Education*, v. 57, no. 1, p. 73–81.
- Trend, R., 2009, Fostering students' argumentation skills in geoscience education: *Journal of Geoscience Education*, v. 57, no. 4, p. 224–232.
- Vallerand, R.J., Pelletier, L.G., Blais, M.R., Briere, N.M., Senecal, C., and Vallieres, E.F., 1992, The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education: *Educational and Psychological Measurement*, v. 52, p. 1003–1017.
- Whitman, W., 1900, *Leaves of Grass*, Philadelphia: David McKay, <Bartleby.com, 1999. <http://www.bartleby.com.142.180.html>>
- Wigfield, A., and Eccles, J.S., 2002, The development of competence beliefs, expectancies for success, and achievement values from childhood through adolescence. in Wigfield, A., and Eccles, J.S., eds., *Development of Achievement Motivation*. A Volume in the Educational Psychology Series: San Diego, CA: Academic Press, p. 91–120.
- Wolters, C.A., and Pintrich, P.R., 1998, Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms: *Instructional Science*, v. 26, p. 27–47.
- Zimmerman, B.J., 1998, Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models, in, *Self-Regulated Learning: From Teaching to Self-Regulated Practice*, Schunk, D.H., and Zimmerman, B.J., eds., Guilford Publication, New York, NY, 244 pp.
- Zusho, A., Pintrich, P.R., and Coppola, B., 2003, Skill and will: The role of motivation and cognition in learning of college chemistry: *International Journal of Science Education*, v. 25, p. 1081–1094.